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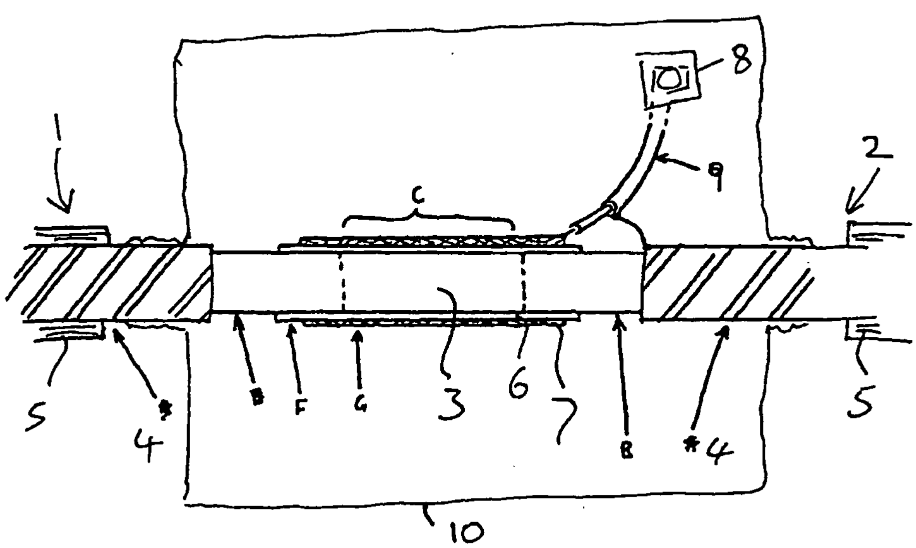
(54) Title: TESTING ELECTRIC CABLES AND THEIR JOINTS



(57) Abstract

A method of testing a jointed high-voltage cable involves establishing a condition in which at least one joint interrupts the metallic return conductor of the cable without interrupting the dielectric screen (3). Test voltage is applied between the cable conductor and return conductor (4), and an instrument (8) sensitive to frequencies above 2MHz is used to observe whether partial discharges are occurring. The method succeeds because the semiconducting dielectric screen is virtually insulating at these frequencies, and avoids the need to strip bands of the dielectric screen (and subsequently reinstate them without facility for testing quality of reinstatement). A joint in the jointed cable is tested by applying a metallic electrode around the joint area (but spaced sufficiently from the metallic return conductor of the adjacent cable length(s)) and connecting the RF test instrument between that electrode (7) and earth.

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Testing Electric Cables and Their Joints

This invention relates to electrical testing of high-voltage electric cables and cable joints (including terminations), primarily (but not exclusively) for use in connection with submarine power cables. Such cables have a load-carrying conductor covered with a "semiconducting" conductor screen (or shield) to ensure a smooth equipotential surface for sound contact with surrounding dielectric (insulation), corresponding semiconducting "dielectric screen" (insulation shield) on the outer surface of the dielectric, a metallic return conductor (or screen) in at least electrical contact with the dielectric screen, and outer protective layers which are immaterial to this invention. Cables with more than one conductor (usually three) are known but are unusual at very high voltages.

Current extrusion technology allows the continuous manufacture of high-voltage cables in lengths ranging from hundreds of metres up to a maximum of around ten kilometres, after which the machinery has to be cleaned to avoid risk of contamination that might cause electrical breakdown. For major submarine power cable projects, this requires that lengths of cable are connected together by "factory" joints, and the quality of such joints needs to be rigorously tested, since a failure after installation is difficult, expensive and time-consuming to repair, or may be virtually impossible to repair in some marine locations.

One of the standard tests for high-voltage cables is a so-called "partial discharge" test in which a test voltage is applied and any local ionisation detected (if possible) by radio-frequency detectors. In principle, such tests can be applied from the end of a jointed length of cable, but the attenuation of radio-frequencies along the cable is such that the sensitivity of the test becomes inadequate at the lengths contemplated. The present approach to this problem is to isolate each joint by removing a length of the dielectric

screen from the cable on each side of the joint, testing the joint by applying test voltage to the dielectric screen of the joint while earthing (grounding) the cable conductor (and the dielectric screen of the cable). This enables the joint to be fully tested without difficulty, but requires the subsequent reinstatement of the dielectric screen without there being any means of similarly testing the reinstatement (which is probably as vulnerable to faults as a comparable part of the joint).

The invention is based on the recognition that the semiconducting dielectric screen of cables is essentially non-conductive at sufficiently high radio frequencies and that partial discharge tests can be made without removing it.

In accordance with the invention, a method of testing a jointed high-voltage cable comprises establishing a condition in which at least one joint interrupts the metallic return conductor of the cable without interrupting the dielectric screen, test voltage is applied between the cable conductor and return conductor, and an instrument sensitive to frequencies above 2MHz is used to observe whether partial discharges are occurring.

For testing of the cable length only, the whole of the joint may be left without metallic return conductor during the test.

For testing of the joint, a metallic electrode needs to be provided (or maintained) around the joint area (but spaced sufficiently from the metallic return conductor of the adjacent cable length(s)), and if this is in contact with the dielectric screen it may be considered a return conductor; however, it need not be in contact, but may be capacatively linked with the dielectric screen through a thin insulation layer.

The electrode may be provided by a foil, sheet or helically-wound tape of copper, aluminium or other suitable material with adequate conductivity at MHz frequencies. Wire

braids or woven or knitted wire fabrics can also be used but may be less desirable as presenting rather greater risk of abrasion.

While a test frequency above 2MHz is sufficient for operation of the invention, we believe that better results are obtained by using even higher frequencies, without limit except practicablity. A practical preferred range is from 30 to 500MHz.

Whether testing cable length or joint, the preferred connection of the test voltage is such that the cable conductor is at high voltage and the dielectric screen and return conductor earthed, so the complication and delay required for reversing connections is avoided, together with the need to provide high-voltage insulation between the joint screen and external earth and high-voltage protection for personnel and instruments in the joint region; further it is possible, when a joint has been made at sea (for instance a repair joint) to apply the method with the high voltage for the test applied to the cable at a termination on land.

Increased sensitivity can be obtained, in some instances, by exposing the joint region (or selected parts of it, with a view to tracing location of detected faults) to high-energy (ionising) radiation during test.

In accordance with normal practice, the joint area should preferably be screened by an earthed metallic enclosure to minimise external noise during testing.

Signals from the electrode will typically be conveyed from the electrode to the measuring instrument by a coaxial cable. It is possible for the electrode and cable to be left in position during subsequent stages of manufacture of the jointed power cable, so allowing the partial discharge test to be repeated at later stages. Eventually (typically immediately before the application of a final armour layer) the connection would be cut and short-circuited to restore metallic continuity.

The invention will be further described, by way of example, with reference to the accompanying drawing in which: Figure 1 is a diagrammatic, partly sectioned, view of a cable joint being tested by the method of this invention.

The joint shown in the figure is formed between two lengths of cross-linked polyethylene-insulated high-voltage power cables 1 and 2 of the kind described. The load-carrying conductor, semiconductive conductor screen and dielectric are connected and reinstated in a conventional manner, and are not visible in the drawing because they are concealed within reinstated semiconductive dielectric screen 3 which is continuous from one length of the cable to the other. The metallic return conductor 4 remains exposed for a short length at each end by cutting back of outer layers represented diagrammatically at 5.

A protective layer 6 of polyethylene sheet is optionally applied to the joint region, which is then formed with a tubular electrode 7 by wrapping with thin copper tape. A radio-frequency detector 8 is connected between the electrode 7 and the return conductor 4 of one of the cable lengths (or an alternative earth point) and is conventional except that it is tuned to accept only signals in the approximate range 30-500 MHz. An earth screen 10 encloses the joint area, and preferably the instrumentation, to protect from external interference; as is well known, it needs to be well bonded to both the return conductors 4 all round their circumferences. Test voltage is applied, in an entirely conventional way at one end of the cable, using a temporary termination at each end.

CLAIMS

1 A method of testing a jointed high-voltage cable comprising establishing a condition in which at least one joint interrupts the metallic return conductor of the cable without interrupting the dielectric screen, test voltage is applied between the cable conductor and return conductor, and an instrument sensitive to frequencies above 2MHz is used to observe whether partial discharges are occurring.

2 A method in accordance with claim 1 of testing a joint in the jointed cable in which a metallic electrode is provided (or maintained) around the joint area (but spaced sufficiently from the metallic return conductor of the adjacent cable length(s)).

3 A method as claimed in claim 2 in which the said electrode is in contact with the dielectric screen.

4 A method as claimed in claim 2 in which the said electrode is not in contact with the dielectric screen but is capacatively linked with it through a thin insulation layer.

5 A method as claimed in any one of claims 2-5 in which the electrode is constituted by a foil, sheet or helically-wound tape that is conductive at MHz frequencies.

6 A method as claimed in any one of claims 1-5 in which the polarity of the test voltage is such that the cable conductor is at high voltage and the dielectric screen and return conductor earthed.

7 A method as claimed in any one of claims 2-5 of testing a joint made at sea in which high voltage for the test is applied to the conductor of the cable at an end on land.

8 A method as claimed in any one of claims 2-5 or claim 7 comprising exposing the joint region (or selected parts of it, with a view to tracing location of detected faults) to high-energy (ionising) radiation during test.

9 A method as claimed in any one of claims 2-5 or claim 7 comprising exposing selected parts of the joint region to high-energy (ionising) radiation during test with a view to

tracing location of detected faults.

10 A method as claimed in any one of the preceding claims in which the frequency range to which the instrument is sensitive is from 30 to 500 MHz.

11 A method as claimed in any one of claims 1-10 in which signals from an electrode are conveyed from the electrode to the measuring instrument by a coaxial cable and in which these are left in position during subsequent stages of manufacture of the jointed power cable, so allowing the partial discharge test to be repeated at later stages, the connection being afterwards cut and short-circuited to restore metallic continuity.

12 A method of testing a jointed high-voltage cable substantially as described with reference to the drawing.

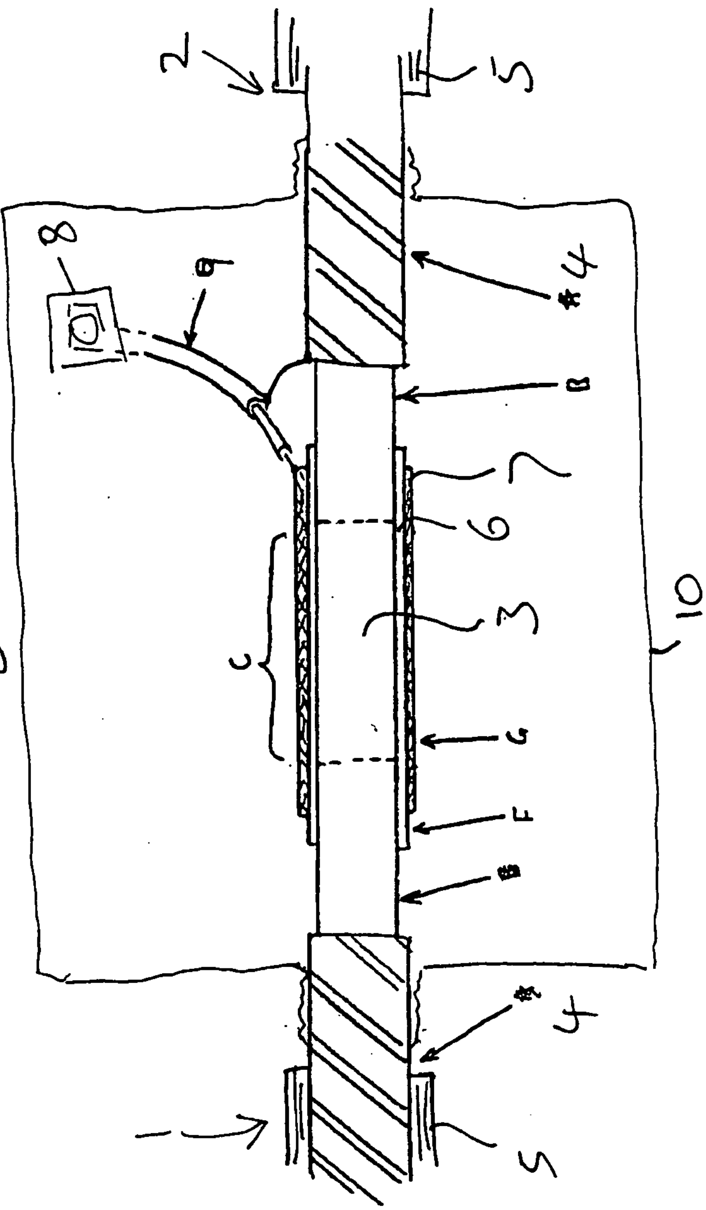

fig 1

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/00769

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01R31/12

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B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 806 676 A (HITACHI CABLE) 12 November 1997 (1997-11-12) column 10, line 14 - line 41; figure 9 column 11, line 1 - line 19; figure 11 column 16, line 49 - line 58; figure 29	1-11
A	WO 94 10579 A (KEMA NV ;STEENNIS EVERT FREDERIK (NL)) 11 May 1994 (1994-05-11) abstract; figure 2	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Information on patent family members

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